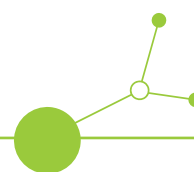


D2.2.1 Report on testing and data collection

Bükk National Park Directorate (BNPD)



Version 1
09 2025

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PILOT ACTIONS - TESTING PHASE

PROJECT PARTNER: Bükk National Park Directorate (BNPD)

LOCATION: Operational area of the Bükk National Park Directorate in Hungary

PILOT SITES: Hór Valley, Forrás Valley caves, Tar-kő Peak, Mátra Mountains, Operational area of the Bükk National Park Directorate in Hungary

PILOT ACTIONS: Monitoring tourist flows (tourist counters, STRAVA app, wildlife cameras, Telekom data), vegetation monitoring (botanical surveys), wildlife monitoring (acoustic sensors, genetical surveys), pollution monitoring (citizen science).



VISITORS MONITORING

STARTING DATE OF EACH METHOD

Monitoring tourist flows with pre-existing tourist counters: 01.04.2023 (project start, data available from 01.04.2021).

Monitoring tourist flows with the STRAVA app: 03.04.2024 (data available from 2019).

Monitoring tourist flows with Telekom data: The data provided covers the total traffic for the period from January 1, 2023, to December 31, 2024, broken down by year, month, and day type (weekday/weekend).

METHODOLOGY DESCRIPTION

Monitoring tourist flows with pre-existing tourist counters

The objective of the visitor monitoring activities is to facilitate the evaluation of tourism impacts on the natural environment, especially vegetation and wildlife. This is hoped to result in better management of visitor flows and infrastructure, ultimately providing the basis for more informed conservation strategies and sustainable tourism practices.

Located at each of the vegetation monitoring sites, automatic counters using an infrared beam from the company ForestVisit Ltd. are present at the split towards the Suba-lyuk cave in the Hór valley (see Figure 1) and the “blue line” designated trail in the Keskeny valley east of the Tar-kő peak (see Figure 2). Moreover, a mobile service analysis will be carried out by Telekom along designated trails at the pilot sites Kékes-North and Csörgő-valley in the Mátra Mountains. Spatially it coincides with the areas of the genetical survey, the educational trail and the participatory monitoring of littering. Tourist flows are further monitored using STRAVA Metro Data along designated trails in all pilot areas.

The raw data with hourly visitor numbers from the automatic counters will be uploaded to the project’s shared database, from where stand-alone or correlation analyses will be possible to conduct, in order to determine peak seasons and hours as well as potential correlation to trampling damages.

Magyar Telekom provides data on the number of visits and the estimated place of residence of visitors to areas designated by BNPI. In total, 6 polygons are the subject of the analysis: Sár-hegy, Totovics, Nagy-Lápatető, Kékes Észak, Parádi legelő, Suba-lyuk.

The data provided covers the total traffic for the period from January 1, 2023, to December 31, 2024, broken down by year, month, and day type (weekday/weekend).

The data product fully complies with the GDPR data protection regulation, both legally and technically, meaning it contains only anonymous, aggregated data, both territorially and temporally.

Magyar Telekom has location data from telecommunication events (calls, text messages, mobile internet usage, etc.) registered on its 2G, 4G, and 5G networks. These events are generated by Magyar Telekom customers and roaming users connected to its network. This raw data includes, among other things, the coordinates of the event, based on which an event is assigned to a polygon.

Residencies in individual areas are a series of events recorded in a polygon where the time elapsed between events is greater than a predetermined maximum value (2 hours). The length of such a stay is the time elapsed between the first and last event of the given event series. A user is considered a visitor if the total length of events from their device within a single day exceeds a predetermined minimum value (1 hour).

A visit is counted if someone appears in a target area on a given day (according to the above description). If someone visits the given target area multiple times in one day, it is counted as one visit. Thus, visitors who meet the criteria for a visit every day of a month will appear every day of that month, i.e., they increase the number of both weekday and weekend visits.



For visitors from Hungary, their place of residence is grouped at the level of geographical middle regions (with Budapest and the areas around the target polygons highlighted separately, see the map below), for Europe at the country level, and for other countries in the world at the level of world regions. The place of residence of domestic visitors is estimated from the locations of their nighttime stays in the 6 weeks preceding the visit, while the place of residence of roaming visitors is calculated based on MCC (mobile country code).

Division of Hungary into regions:

To find local residents, special polygons have been designated around the target areas. The starting area of visitors who live nearby is the same as the name of the target area (see Figure 3.).

The number of visits is aggregated and transferred by place of residence, target area, year, month, and day type (weekday: Monday to Friday, weekend: Saturday and Sunday). Special public holidays are not listed separately in the analysis, meaning public holidays falling on weekdays are counted as weekdays, and working Saturdays are counted as weekends. The analysis includes only trips generated by devices that are mobile phones or tablets.

Aggregates with a cardinality of less than 10 cannot be transferred in accordance with data protection standards, so they are masked with a value of "<10" in the transferred data.

Data Product:

The data is transferred in csv format; one file is provided.

The data set (named: MT_BNPI_res_2023_2024.csv) contains the traffic measured between the polygons for the above-mentioned period, with the following columns:

Column Name	Description
country	Country
place_of_origin	Starting area
target_area	Name of the target polygon
year	Year
month	Month
day_type	Weekday / weekend breakdown
traffic	Number of visits

Table 1. Data description of Telekom Cellular data

STRAVA METRO data (monthly and yearly, bikes and hikes) is collected from the relevant protected areas (Bükk National Park, Mátra Landscape Protection Area) and sent to project partner Carinthia University of Applied Sciences (CUAS) for analysis.

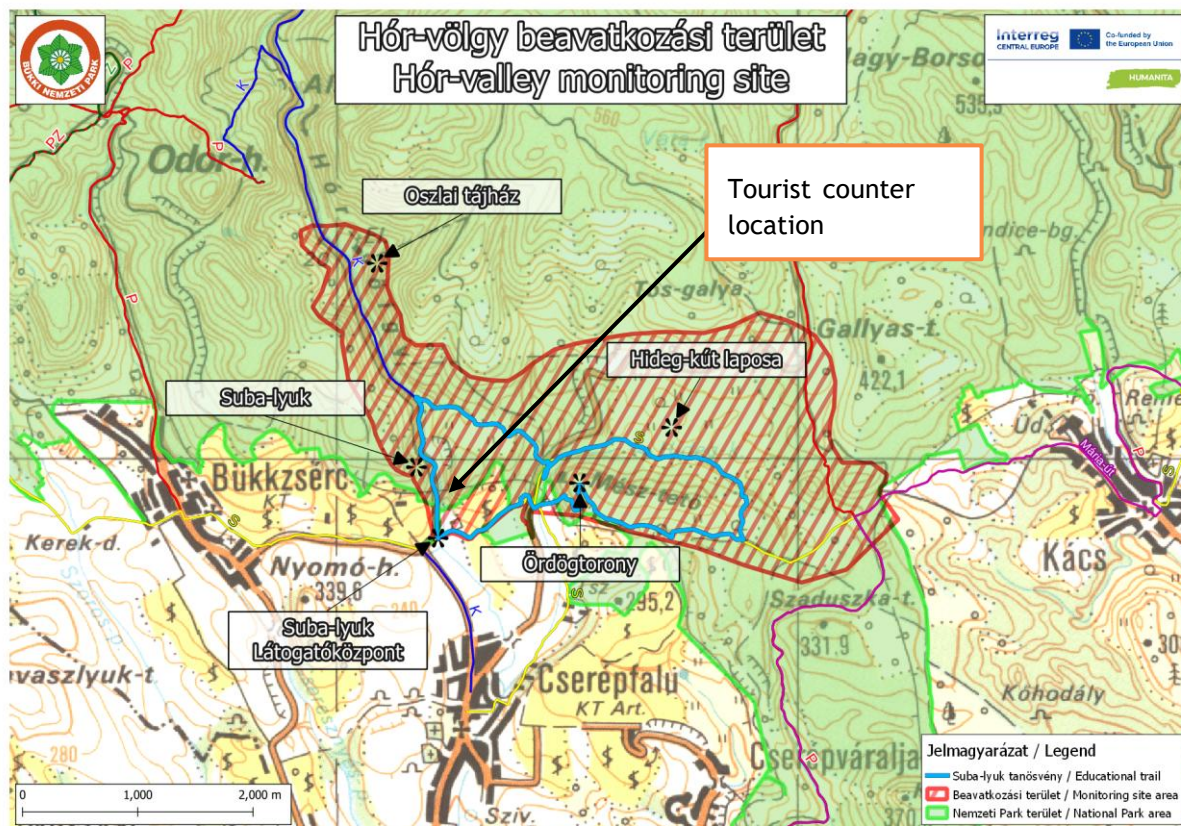


Figure 1: Hór-valley monitoring site with the location of the automatic counter.

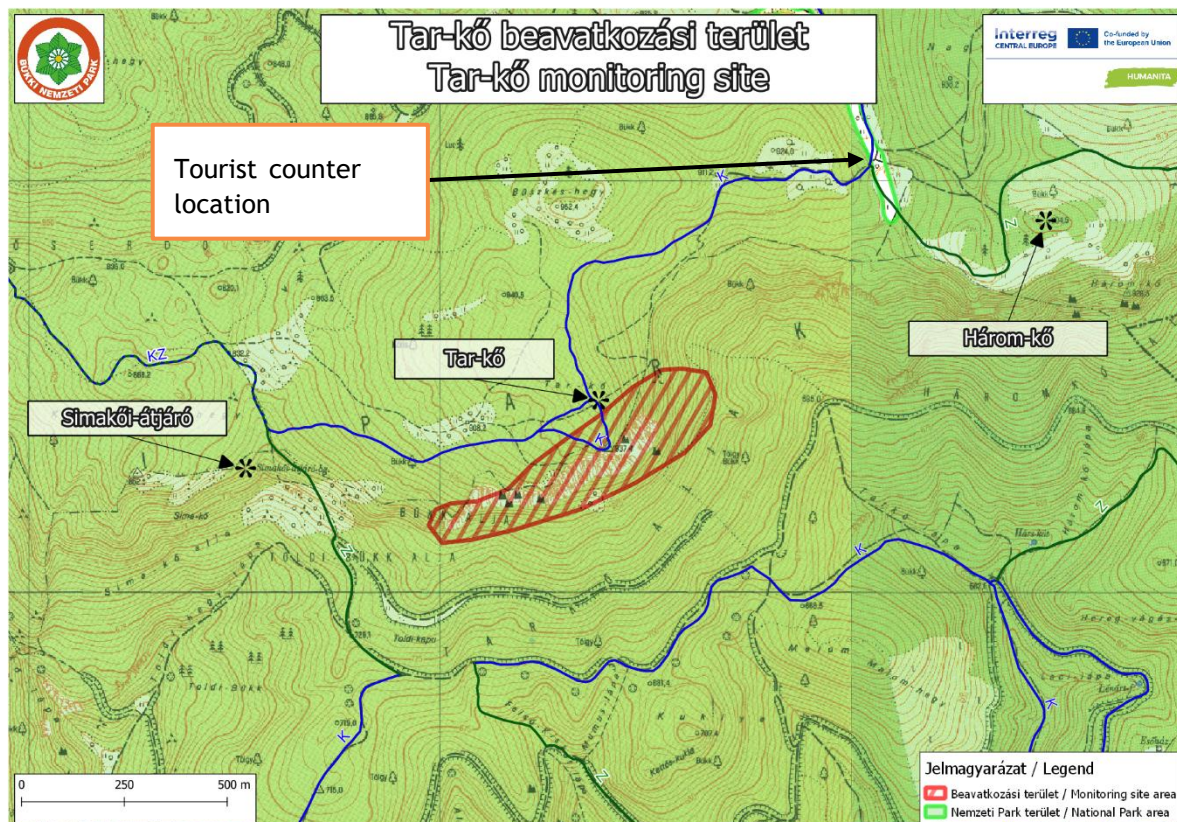


Figure 2: Tar-kő monitoring site with the location of the automatic counter.

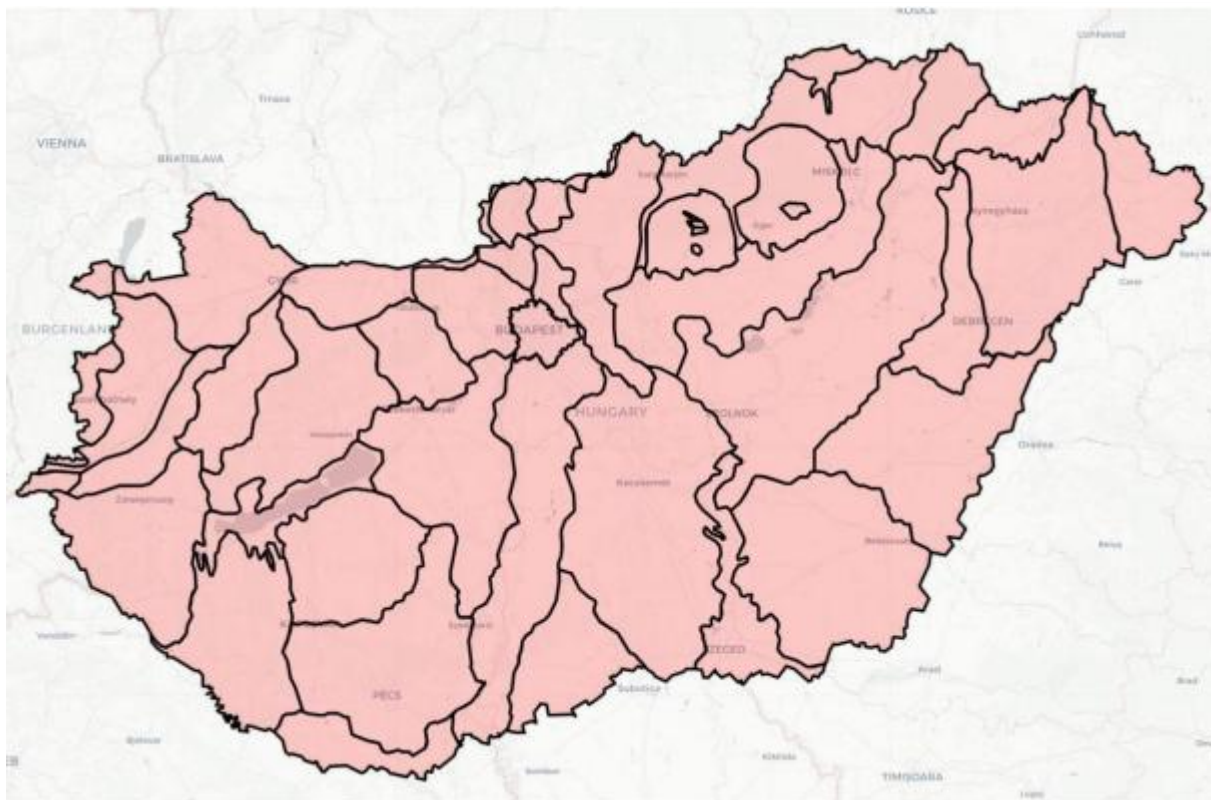


Figure 3: Regions used for the analysis of domestic visitors from the Telekom cellular data.

RESULTS AND OBSERVATIONS

The data from the automatic counters up until 01.09.2025 was collected from the service provider and sent to project partner University of Parma (UNIPR). Data can easily be collected from the service provider upon request or at agreed intervals.

With regards to the Telekom service provider data, we have received and uploaded the data from 01.01.2023 to 01.12.2024. Based on the detailed analysis of the visitation data for 2023 and 2024, here are the conclusions for each target area, combining overall trends, seasonal patterns, and visitor origins. To see the spatial distribution of the target areas refer to Figure 4.

1. Kékes Nort site

Conclusion: A **stable and highly Domestic-focused** area that functions as a traditional summer getaway. Its consistent visitation numbers (only -1.4% change) are primarily supported by a large **Domestic base (78.5% share)**. International visitors mainly originate from nearby **Germany, Romania, and Slovakia**. The near-perfect **50/50 weekday/weekend split** suggests it caters equally well to standard weekend tourism and longer summer breaks.

2. Nagy-Lápafő site

Conclusion: This area is **overwhelmingly domestic-reliant (95.0% share)**, serving almost exclusively the local market. Its unique peak pattern includes both **summer (July, August)** and **mid-winter (January)**, indicating a **dual-season function** likely related to winter sports or activities. International visitation is minimal and dominated by immediate neighbours like **Germany, Romania, and Slovakia**.

3. Parádi meadows site



Conclusion: Parádi meadows experienced a notable **decline (-4.1%)** but retains a highly domestic base (82.4% share). Its distinctive peak in **November**, alongside the **summer months (July, August)**, suggests a strong appeal for **autumnal/early winter events or scenery**. International visitors are a mix of Central European neighbours and Western European markets like the **United Kingdom**.

4. Sár-mt site

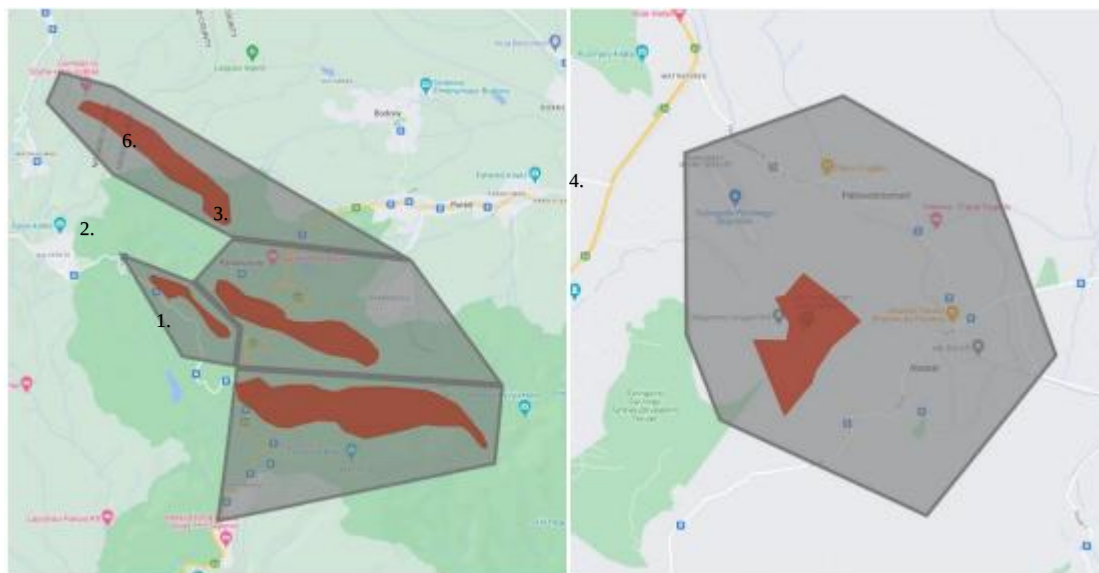
Conclusion: A **growing destination (+3.9% overall)** showing positive signs of increasing international appeal (International share rose to 28.4%). Its international visitor origins are unique due to a **high number of visitors from Ukraine**, alongside **Germany and Romania**. The area shows the **strongest preference for Weekday visits (57.0%)**, suggesting it is a favoured location for structured or mid-week travel, perhaps driven by groups or local events.

5. Suba-lyuk site

Conclusion: This is the **fastest-growing area** in the dataset (+15.3% overall growth), successfully attracting both domestic and international visitors. It is a dominant **summer destination** (August, June, July hotspots) with a relatively diversified international market, including Northern European countries like **Sweden** and Central European sources like **Germany and Poland**. The balanced weekday/weekend split reflects its broad appeal as a destination.

6. Totovics site

Conclusion: Totovics is the area is characterized by a sharp **decline in visitation (-12.6%)**, particularly during its core **summer months (July, August)**. It is the **most domestic-dependent area (94.6% share)** and sees minimal international traffic, mainly from **Romania and Germany**. The decline in both visitor types suggests a need for re-evaluation of its offerings or promotion to address the negative trend.



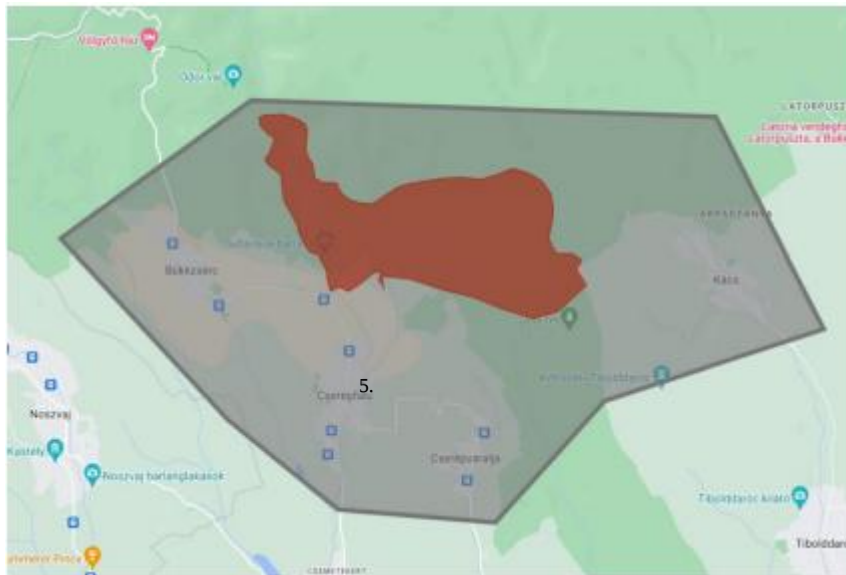


Figure 4: Polygons defined by Telekom for the pilot sites.

STRAVA METRO data for the project duration is analysed by CUAS.

FUTURE DEVELOPMENTS

BNPD is in the process of setting up a new monitoring system, where inputs from multiple sources will be able to be included, aiming to get a clearer view of the usage and pressure on our pilot action sites. Testing new data sources like cellular data or the STRAVA METRO system is crucial to explore the possibilities and limits of each method.

Further, it is important to have more on-site counters regarding using these systems to have constant, relatively accurate data to put them in relation to the user numbers counted for example in the STRAVA METRO database.



VEGETATION MONITORING

STARTING DATE

The monitoring activity started on 01.05.2024 and was completed on 15.09.2025.

METHODOLOGY DESCRIPTION

The botanical surveys carried out by an external expert aim to provide an impact assessment of trampling damages and the introduction of invasive species along tourist routes. The sampling sites are around the Suba-lyuk cave in Hór valley and where hikers rest around Tar-kő peak with vegetation in different forests and on grassland types at the centre of the study. The monitoring activity encompasses a habitat mapping of sample sites, a mapping of tourism impacts and an assessment of the impact of tourism on vegetation.

The task involved **designating 3 pairs of transects in both sample areas where coenological surveys were to be conducted in 2024 and 2025**. Each transect was required to have a minimum of 4 survey units (quadrats, with size adjusted to the habitat type being sampled). The core table (Microsoft Excel spreadsheet) for recording the survey results was to be provided by the client. The survey periods were: twice a year (between May 1st and May 20th, and between June 15th and July 5th).

In 2024, **three 5-metre long transects (I-III) were designated in Hór-völgy, and three (IV-VI) in Tar-kő**, ensuring that a footpath traversed each transect. The coordinates of the start and end points of the transects were recorded for precise re-surveying. Stable points along the transect (rock outcrop, tree) were marked with **red spray paint** and their positions described (see Table 2).

Table 2: Parameters of the transects marked in the Hór valley and Tar-kő

Table 2: Parameters of the transects marked in the Hór valley and Tar-kő				
Transect				
Hór-valley	Points	Coordinates	Description	Quadrats
I	Starting point	240501_221 (47.960247 N, 20.530025 E)	<i>Cerasus mahaleb</i> painted, 0 point	quadrats to the right
	End point	240501_222 (47.960259 N, 20.529966 E)	rock painted, 5 m	
II	Starting point	240501_224	stone painted at the base,	quadrats right/down; path at the boundary of 2nd-3rd quadrat
	End point	240501_225	dead tree trunk painted at 4 m	
III	Starting point	240501_226 (47.961057 N, 20.531314 E)	path steps painted (0. m)	quadrats downwards
	End point	240501_227 (47.961061 N, 20.531289 E)	<i>Acer campestre</i> painted at 2 m,	
Tar-kő	Points	Coordinates	Description	Quadrats



IV	Starting point	240501_228 (48.056421 N, 20.460414 E)	starting point below the path	quadrats placed to the right
		240501_230 (48.056473 N, 20.460377)	painted stone on the path,	
		240501_229 (48.056454 N, 20.460370 E)	painted, fallen tree	
	End point	240501_231 (48.056487 N, 20.460378 E)	painted Fraxinus at 7 m,	
V		240501_233 (48.056477 N, 20.461844 E)	0 point, painted stone	
		240501_234 (48.056494 N, 20.461815 E)	painted stone at 2.2-2.3 m	footpath in V/2
		240501_235 (48.056499 N, 20.461806 E)	end in Spiraea, not marked	
VI		240501_236 (48.056153 N, 20.461396 E)	painted stone, 5. m	
		240501_237 (48.056150 N, 20.461406 E)	painted stone at 4.4 m	
		240501_238 (48.056134 N, 20.461422 E)	painted stone at 2.5 m	
		240501_239 (48.056110 N, 20.461419 E)	painted stone at 0 m,	

Along each transect, **five contiguous 1×1 metre quadrats** were placed in the recorded direction, and the vegetation within them was surveyed. The quadrat identifier was formed from the transect ID and the quadrat's serial number within the transect (e.g., I/1 for the 1st quadrat in transect I).

Within the quadrats, the **percentage cover of each plant species** was recorded, along with the cover of **moss, litter, soil, deadwood, and bare ground**. The **current phenological state** of every plant species present was also recorded.

For the overall assessment, the **highest cover value recorded across the two surveys** was used for each species. For the phenological analysis, a simplified categorisation distinguished between species present in a **vegetative** and a **generative** state.

Results of the Coenological Investigation of the Impact of Tourism

The surveys were performed using the specified methodology in both 2024 and 2025, allowing for a comparison of the two years' data. The following parameters were compared as suggested:

- **Species number** (at transect and quadrat level, number of species)
- **Vegetation cover** (at transect and quadrat level, number of cover units)



- **Social Behaviour Types** (based on Borhidi 1993 - specifically the ratio of species indicative of natural and disturbed habitats; at transect and quadrat level)
- **Evaluation of phenological data** (differences in flowering can be partly attributed to the impact of tourism)

The surveys in 2025 took place on **May 7th and June 16th**. The detailed coenological data, their arrangement into site-specific tables, the comparison of the two years' surveys, and the metadata are contained in the accompanying Excel spreadsheet.

Comparison of Species and Species Numbers

In the **Hór-völgy I site (rock grassland)** transect, **8 new species** were recorded in 2025, and **14 species recorded in 2024 were not found in 2025**. The total number of species was **67 in 2024 and 61 in 2025**. The appearance of the weed *Senecio vernalis* is noted, though its presence is attributed to its national expansion rather than necessarily tourism.

In the **Hór-völgy II site (thermophilous oakwood)**, **40 species were confirmed in 2024, and 32 in 2025**. The disappearance (or retreat) of several species may be due to the **early and prolonged drought**. The footpath affects quadrats II/2 and II/3, which had 30 species in 2024 and 23 in 2025.

The **Hór-völgy III site (rock forest)** transect showed **17 species in 2024 and 19 in 2025**. The tourist path affects quadrat III/1, where **4 species were detected in 2024 and 9 in 2025**.

The **Tar-kő IV site (beech forest)** transect had **38 species in 2024 and 46 in 2025**. Quadrat IV/1, affected by the tourist path, recorded **22 species in 2024 and 25 in 2025**.

The **Tar-kő V site (steppe meadow)** transect showed **60 species in 2024 and 57 in 2025**. The footpath passes through quadrat V/2, where the species count was **34 in 2024 and 25 in 2025**.

The **Tar-kő VI site (rock grassland)** transect recorded **65 species in 2024 and 51 in 2025**. Quadrat VI/5, traversed by the footpath, had **27 species in both years**, and a high proportion of weeds and disturbance-tolerant species.

Comparison of Cover Values

No evidence of a specific, systematic trend or a dominant underlying factor was found to explain the changes in cover and frequency, which are **highly diverse**.

In the **Hór-völgy I site**, the overall cover and frequency of *Allium flavum* both **doubled**.

In the **Hór-völgy II site**, the increase in *Anthriscus cerefolium* cover is notably more spectacular, increasing roughly **20-fold**, becoming the dominant species. The cover and frequency of *Galium aparine* also increased significantly.

In the **Hór-völgy III site**, *Anthriscus cerefolium* newly appeared, and the cover and frequency of *Galium aparine* and *Lapsana communis* increased significantly.

In the **Tar-kő IV site**, the most significant change was the **increase in the total cover of *Stellaria holostea* from 0.7 to 25**.

Comparison of Social Behaviour Types

The changes in the number of species belonging to **natural associations, disturbed habitats, and weeds** were generally proportional to the overall species reduction in **Hór-völgy I and II**, suggesting a general species reduction (possibly due to drought) rather than increased disturbance.

In **Tar-kő V**, while the number of natural species decreased, the number of **weeds increased from 3 to 6**, and the cover of both weeds and disturbance-tolerant species increased.

Comparison of Phenological Data



The number of species confirmed to reach the generative phase was the same in both years (22) in the Hór-völgy I site. In the Hór-völgy II site quadrats affected by the footpath (II/2 and II/3), the count shifted from 13 generative and 13 vegetative species in 2024 to 9 generative and 14 vegetative species in 2025.

RESULTS AND OBSERVATIONS

The investigation examined the impact of tourism in the Bükk National Park across three scales:

- **Large-scale (Habitat Mapping):** Both areas are dominated by natural, high-quality habitats. The Tar-kő habitat map shows small, degraded, trampled patches near the viewpoint, indicating concentrated tourist pressure.
- **Meso-scale (Mapping of Tourist Effects):** Increased trampling is observed along designated tourist paths leading to attractions. In Hór-völgy, infrastructure (railing, bench, steps) was renovated or newly installed in 2025. Signs of impact (littering, occasional toilet areas, cairns) are concentrated near the paths and attractions, but their impact is minimal further away.
- **Small-scale (Coenological Investigation):** The impact of footpaths on plant associations is detectable but not significant, confined to the immediate vicinity (0.5-1 m wide). The main effect is the presence of bare soil surfaces and a small number of disturbance-tolerant species and weeds in the affected quadrats. A key concern is the potential for non-native invasive plant species to spread along these paths.

The path to the Suba-lyuki-barlang (cave) is the main route. In 2025, a railing was installed along the steep section, and a new bench with a railing was established nearby. Traces of tourist presence include



(occasional) toilet areas and discarded objects. Tourist activity is concentrated at the cave entrance and along the path, but unmarked footpaths also lead further away (Figure 5).

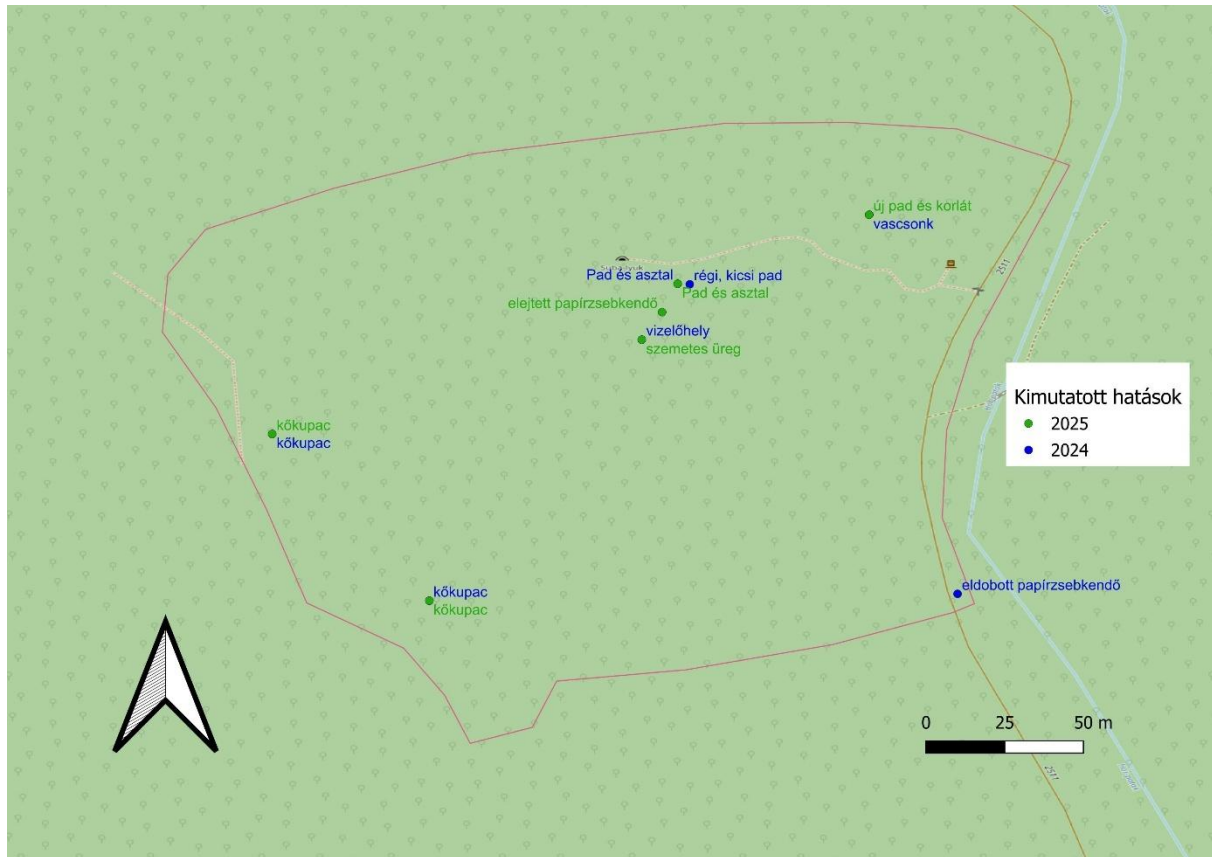


Figure 5: Tourism impacts in the Hór-valley area

The area is affected by a **single designated hiking trail** (▲ and L markings). Increased pressure and **pronounced trampling** are felt along the section around the **viewpoint**, leading to changes in grassland composition. An **occasional fireplace** and signs of use as an occasional toilet are present near the viewpoint. Current visitation to the **Tar-kői-kőfülke (rock niche)** is minimal (Figure 6).

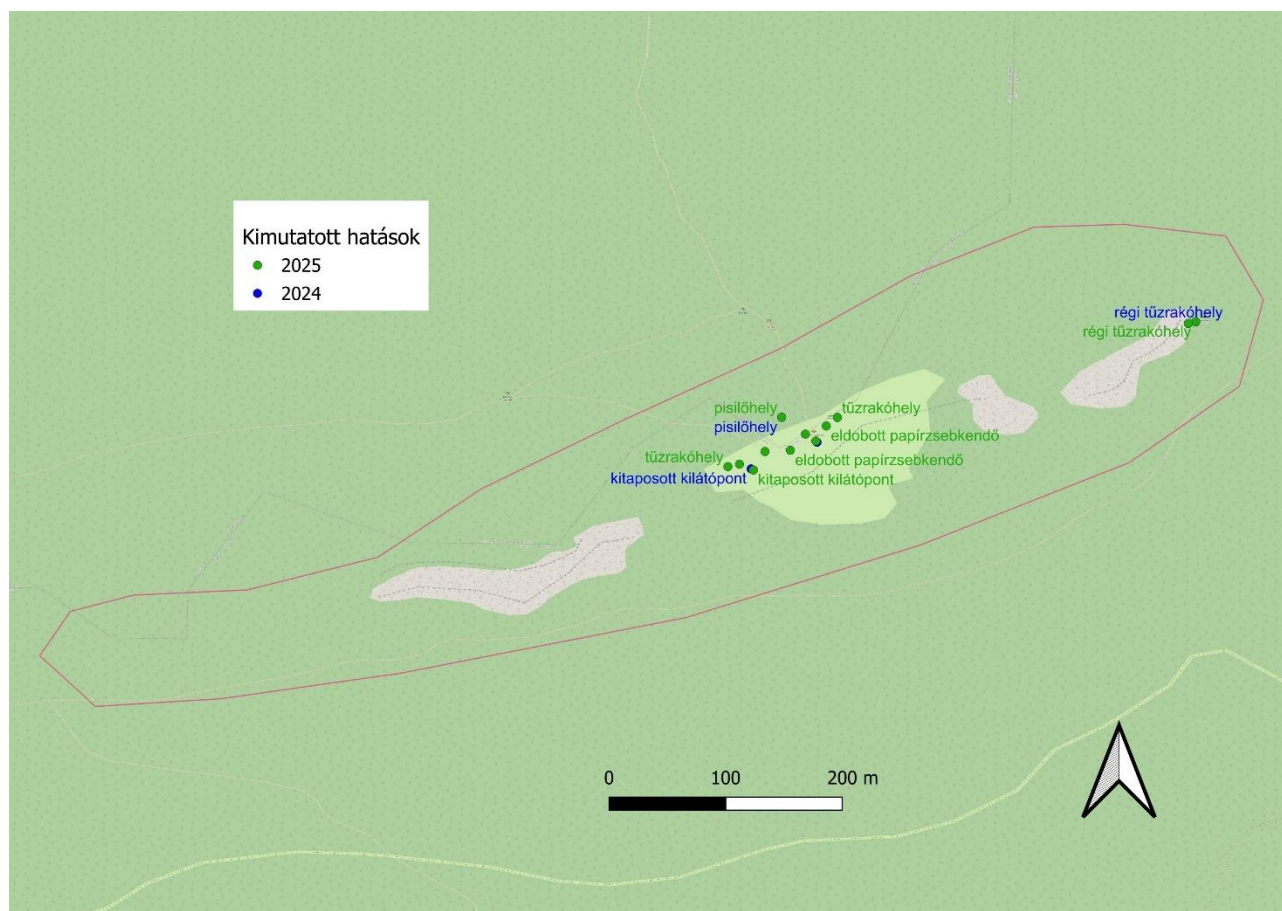


Figure 6: Tourism impacts in the Tar-kő area

The two-year comparison highlights that, in addition to tourism, significantly larger factors are influencing vegetation composition, including the continuous drought in 2025, climate change, and regional changes in species ranges. The recorded data provides a foundation for future, longer-term studies to isolate the effects of local tourism from broader environmental changes.

FUTURE DEVELOPMENTS

Based on the findings of the 2024-2025 vegetation monitoring report, future developments should focus on three key areas: **expanding the research** to isolate variables, implementing **targeted management actions** to mitigate observed impacts, and enhancing **public engagement** to prevent future degradation.



WILDLIFE MONITORING

STARTING DATE

Genetical surveys on amphibians: April 2024.

Acoustic monitoring of caves: June 2024.

METHODOLOGY DESCRIPTION

Bat monitoring

Wildlife monitoring is expected to shed light on the effects of human disturbance on bat populations and the possible link between the prevalence of humans in certain areas and amphibian diseases.

BNPD is home to caves that are important for the breeding of several bat species. The cave is relatively unique as it is in proximity to settlements and frequently visited by tourists, yet still used by large bat populations. Human disturbances range from noise pollution, littering and defecation to illegal firepits in front of the caves. It is suspected that human disturbances could lead to rendering the caves uninhabitable for bats in the future. To monitor the potential impact, four acoustic sensors of the type AudioMoth AM-FH lent by CUAS were positioned (see Figure 7) at the entrance and inside the Kecse-lyuk cave in the Forrás valley (see Figure 8). Their capabilities to detect human presence and noise disturbances have been tested both in the open and in the caves.

The devices monitor human and bat activity in the cave from 60 minutes before sunrise to 60 minutes after sunset. In addition to operating the data recorders, the data of the currently observable bat population is also recorded.

Bat Species observed:

- Lesser horseshoe bat (*Rhinolopus hipposideros*)
- Greater horseshoe bat (*Rhinolophus ferrumequinum*)
- Schreiber's bat (*Miniopterus schreibersii*)
- Mediterranean horseshoe bat (*Rhinolophus Euryale*)

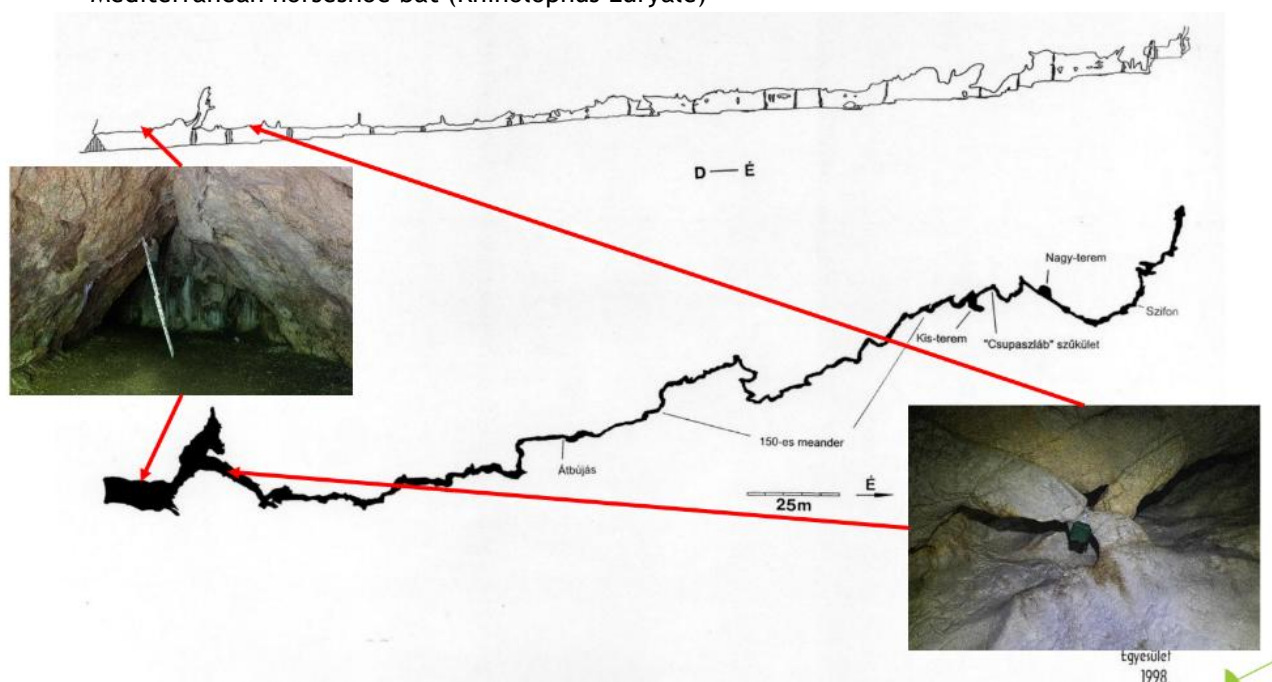


Figure 7: Installation of the acoustic sensors in the Kecse-lyuk cave.

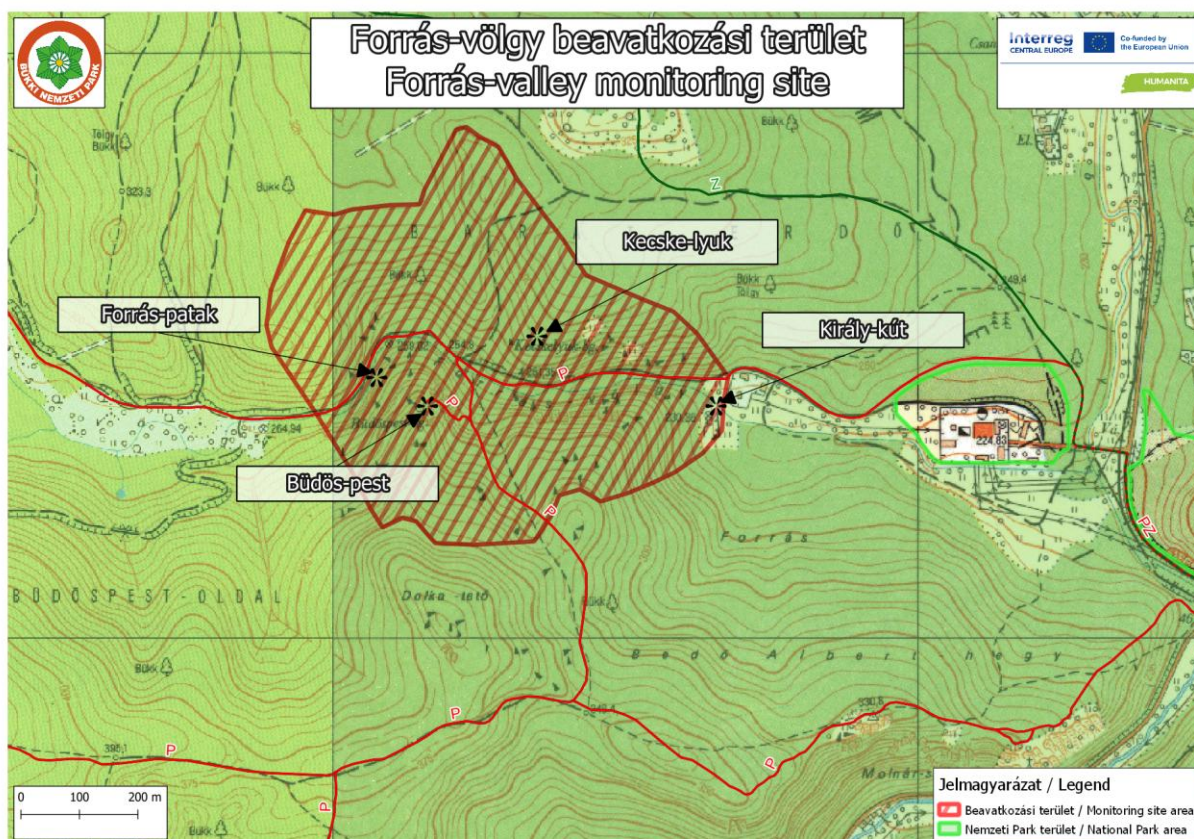


Figure 8: Map depicting the monitoring site in Forrás valley, also showing the location of the Kecske-lyuk caves in which bat monitoring takes place.

Ambibian Monitoring

Furthermore, the Hungarian Ornithological and Nature Conservation Foundation was subcontracted for a survey on tourism pressures on amphibians. The focus is on the spread of the fungal pathogen *Batrachochytrium dendrobatidis* causing Chytridiomycosis in yellow-bellied toads (*Bombina variegata*) as well as Ranavirus in the common frog (*Rana temporaria*). Both are fatal diseases among amphibians and are linked to the population collapse and even extinction of many species worldwide. There are concerns about the potential role of tourism in the spreading of diseases as the pilot site Mátra Mountains is subject to the presence of those pathogens and is simultaneously a popular Hungarian tourist area. The consequent monitoring covers touristic and non-touristic amphibian habitat areas adjacent to trails, dirt roads and small puddles in Kékes-North and the Csörgő valley in the Mátra Mountains. There are three control sites in the same region: Totovics, Nagy-lápafő and Parádi-legelő (see Figure 9). The evaluation of the samples collected is expected to show if there is a significant difference between the prevalence of pathogens for samples collected close to tourist paths in comparison with those taken in areas with little tourist activity.

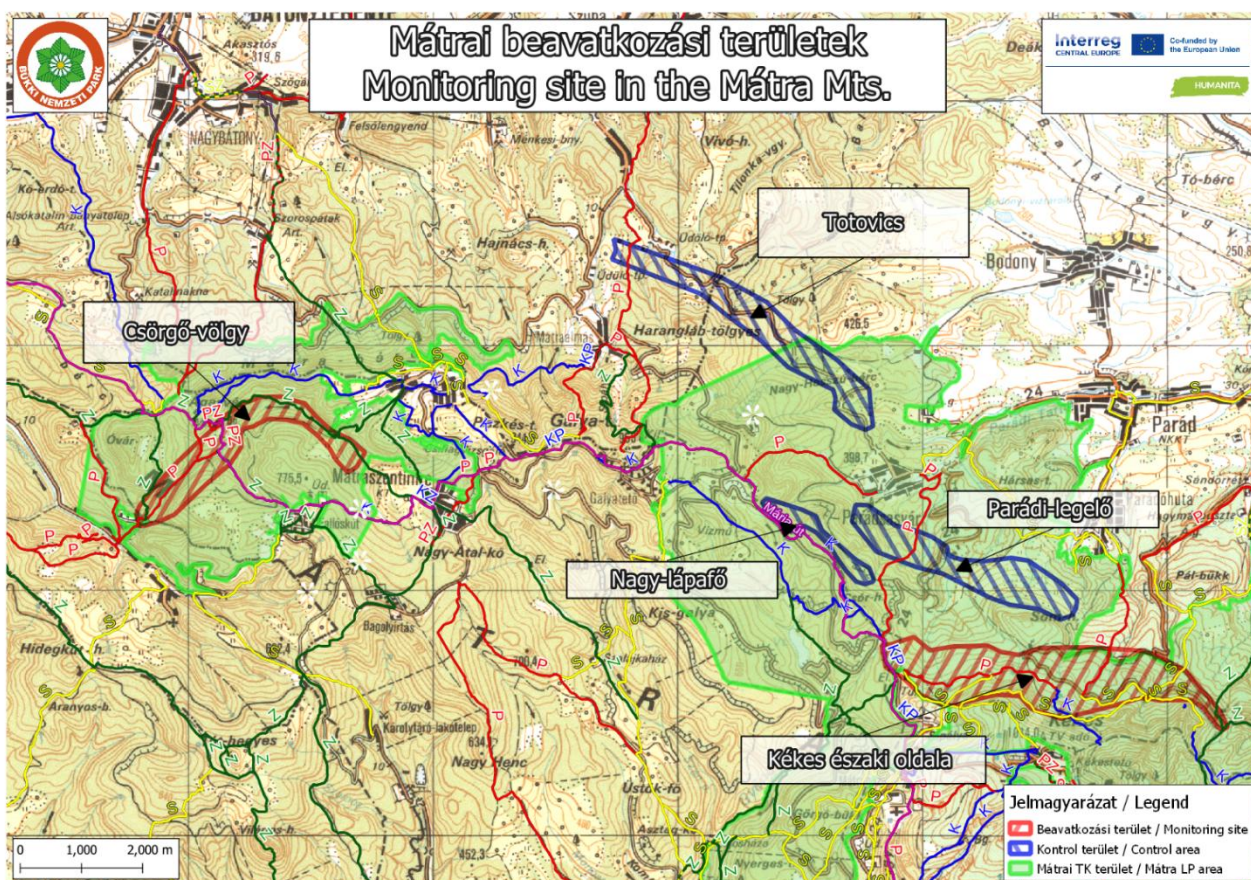


Figure 9: Map showcasing the pilot and control sites in the Mátra Mountains.

RESULTS AND OBSERVATIONS

One difficulty in the wildlife monitoring testing stage for bats so far has been the late arrival of bat populations in the caves. Also, the large amount of data paired with a short battery life makes a continuous recording on the acoustic sensors challenging with the system being designed to start recording after the camera trap is tripped.

In the course of the amphibian monitoring in the Mátra Mountains, 150 samples from yellow-bellied toads (*Bombina variegata*) from touristic and non-touristic areas were collected, exceeding the project commitment of 100. Further, 75 samples of the common frog (*Rana temporaria*) were taken in touristic areas with a project commitment of 50 samples. The sampling from non-touristic areas will take place in autumn, also with a minimum of 50 samples. Concerning the Ranavirus testing, a problem that occurred was the unusually low number of common frogs in 2024 as well as their fast reproduction cycles. This is why at first, only around one-third of the samples committed to have been collected.

FUTURE DEVELOPMENTS

Regarding the bat monitoring, data collection is finished. The raw data of the audio files are currently analysed and are being converted to excel files to be uploaded to the Humanita shared database.

For the amphibian monitoring, we are currently waiting to get the laboratory results back. Their expected arrival is early October 2025. As mentioned above, to gain a comprehensive understanding of visitor movement and origin (national or international) in relation to amphibian disease monitoring, there is also a plan to utilise mobile service data for in-depth cooperative analysis.



POLLUTION MONITORING - Inaturalist project

STARTING DATE

18.07.2024

METHODOLOGY DESCRIPTION

Alongside the botanical surveys, an iNaturalist project has been set up. By providing a platform in which the public can input and share their observations, it was hoped this could generate a more comprehensive data set. As a collection project, any observations that met the criteria could be included. One key criterion was that only invasive species would be included. The list of eligible invasive species was based on ... Tourism provides a pathway for the spread of invasive species, with tourists acting as vectors for propagules. This illustrates the tension between tourism and conservation. Collecting data on these species could reveal the scale of their interaction, identify the foci of spread, and inform management strategies. Moreover, this focus on invasive species circumvents a potential risk of iNaturalist, in which revealing the locations of protected species could undermine efforts to protect them. However, as disclosing the locations of invasive species does not pose a threat, this ensures that data collection supports conservation rather than unintentionally compromising it.

The study area was defined to extend just beyond the borders of Bükk National Park, encompassing the pilot sites of Hór Valley and Forrás Valley. This boundary includes surrounding villages, as the park's remoteness limits potential citizen participation. Engagement is essential for the success of citizen science, making accessibility a priority. Additionally, most tourists stay in these villages, so the spread of invasive species often originates from these areas, justifying their inclusion within the project boundary.

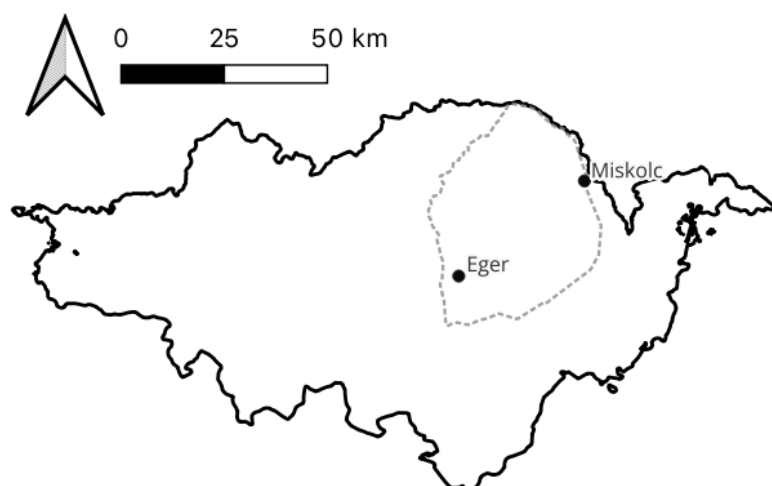


Figure 10: The solid line represents the total area that BNPD is responsible for, whilst the dashed line represents the iNaturalist project boundaries. Within this there are two major towns, Eger (population: 49,182) and Miskolc (population: 147,533) alongside several villages.

Only research quality grade data was included, hence there had to be a minimum of two agreeing identifications. For each uploaded observation data including the species name, date observed, GPS coordinates and a photo were collected. Also, there was an option to provide further comments, with some noting their size, proximity to other species and location details.



Requiring a photo is a key advantage of iNaturalist, enabling verification of observations while also providing phenological insights. This has ramifications on the management of invasive species, with the chosen technique often dependent on phenological factors, such as blossoming and seed production, which can be inferred from photographs.

When promoting the project, it was requested that photos should be taken from further away. This helps provide more contextual information. iNaturalist does not provide an option to record the population size, instead only its presence is a record. A larger field of vision helps to quantify this. Also, there are also biases in which species are photographed, it is more likely that the flowering one in a cluster is photographed, providing misleading information about their phenology. As such taken a photo further away provides a more comprehensive outlook.

RESULTS AND OBSERVATIONS

So far there has been a total of 91 contributors, who have observed 661 plants, comprised of 48 species.

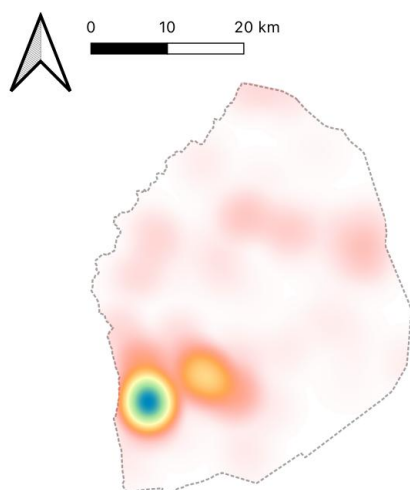


Figure 10: Heatmap of iNaturalist observations using kernel density analysis.

This heat map shows a clear spatial bias, with most observations surrounding Eger. Accessible and popular locations tend to have more observations. As Eger has a higher population, this contributes to their being more invasive species documented in this area. The adhoc nature of their documentation limits the use of the data collection, with its inconsistency making it challenging to reach a strong conclusion. Frequent, high-resolution observations are needed to accurately track the spread of invasive species. Even in Eger, where the highest number of invasive species has been recorded, the frequency of observations is insufficient to clearly delineate their spread. This limitation is partly due to the project's recent start, which has restricted the recruitment of citizen scientists. Nonetheless, the collected data remain valuable for management, enabling early detection and rapid response to problematic species.

FUTURE DEVELOPMENTS

Continued promotion of iNaturalist, including recruitment of participants through schools, guides, and park rangers, could expand the project's reach. As more observations accumulate, challenges regarding spatial and temporal resolution should diminish, allowing for improved tracking of invasive species spread and a better understanding of their dynamics.



POLLUTION MONITORING - Hulladékradar app

STARTING DATE

18.07.2024

METHODOLOGY DESCRIPTION

The implementation of pollution monitoring is intended to enhance the active management of waste, concurrently fostering visitor awareness and encouraging environmental stewardship. It is designed as a citizen science project using the mobile application Hulladékradar for all the operational areas of BNPD in collaboration with the app developer, the Hungarian Ministry of Energy.

RESULTS AND OBSERVATIONS

As part of our cooperation with the Hungarian Ministry of Energy, their colleagues were kind enough to gather the registered illegal trash dumps in 2022 and 2023. As the operational area of BNPD exceeds the protected area borders, they included all the occurrences in Heves and Borsod-Abaúj-Zemplén county (for numbers, see Table 3). Half of Nógrád County is also part of the BNPD operational area, but within the HUMANITA project, there are no pilot sites there. Nevertheless, the Nógrád data could be collected for analysis as well.

Table 3: Number of registered illegal trash dumps in the two counties of Heves and Borsod-Abaúj-Zemplén.

	2022	2023
Heves county	91	116
Borsod Abaúj Zemplén county	303	155

As the majority of the protected area parcels are not in the stewardship of the BNPD, rather the two state-owned forestry companies (Egererdő Zrt. in Heves c. and Északerdő Zrt. in Borsod c.), notifications about dumpsites preceding the cooperation did not come directly to us (for numbers, see Table 4). For clarification, the BNPD is the responsible authority for nature protection within its operational area and must approve changes which would impact the natural state, regardless of ownership (both state, municipal and private land).

Table 4: Number of registered illegal trash dumps in the areas owned by the two state-owned forestry companies.

	2022	2023
Egererdő Zrt area	11	1
Északerdő Zrt area	13	0

One difficulty in acquiring the data on the illegal dump sites in relevant areas is the filter system of the administrator site of the application. As the application is not primarily designed to collect data from protected areas, there is no possibility to filter it easily. Rather, there is an option to filter the database to settlements and area codes, which after downloading must be further filtered with the area codes of parcels found in protected areas, to arrive at the number and characteristics of dump sites in protected areas.

This process of filtering enabled dump sites within protected areas to be selected. This is essential given that most dumpsites were in urban areas. As such, it was necessary to remove these sites, so that the ones within protected areas could be focused on.

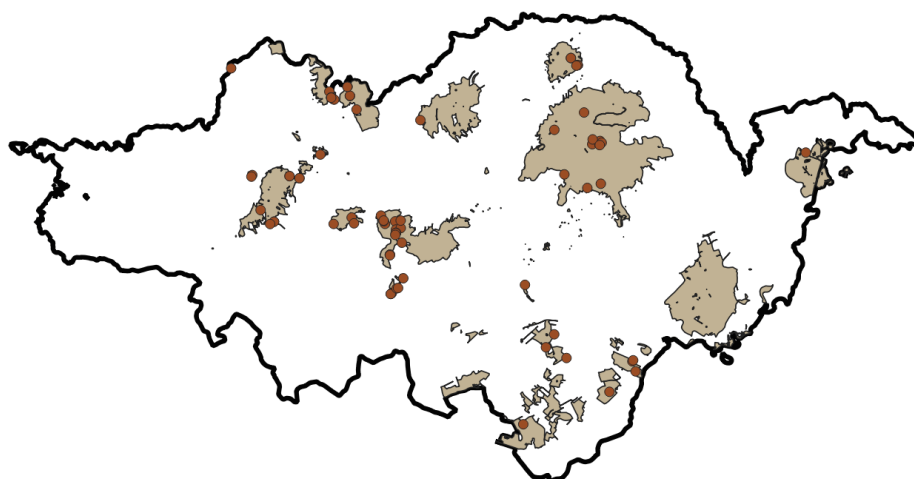
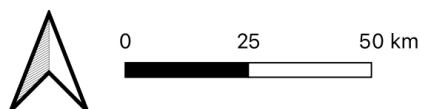


Figure 11: Dump sites within protected areas.

Within the protected areas there are clear clusters, something which can be made clear through density analysis.

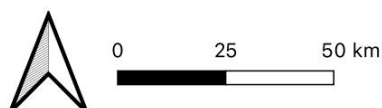


Figure 12: Weighted density analysis of dumpsites.

The app accommodates the different dimensions of dumpsites. The data set groups these as less than 1m^3 , 1 to 5m^3 and over 5m^3 , categories necessary due to the nature of citizen science, in which estimation is required due to lack of measurement equipment. Incorporating these categories into the density analysis, in which over 5m^3 is weighted heavier than less than 1m^3 . Analysing these clusters, points A and B stand



out, at both points there are roads suggesting that these are key areas for dumpsite locations. This may be a result of these locations being easier to access and drop litter at. This is highlighted by 24% of dumpsites within protected areas being found with 10m of a road, or 48% within 20m. This increased accessibility means illegal dumping is more likely in these locations. The size of the dumpsites further indicates that these are likely instances of fly-tipping rather than incidental littering by tourists, as smaller litter is less likely to be reported. As such it is not possible to determine whether tourism increases the amount of litter.

The primary purpose of the app is to encourage waste removal, evident in the apps design, with users having to provide data on the accessibility of the dump sites, such as whether it can be accessed by foot or car. This directly helps with protected area management, with it highlighting areas where waste removal is required. All reports were checked, with 52% resulting in litter being cleared. For other instances, it was misreported, with it either not waste or absent. The rest of cases were in progress.

One downside is the reliance on citizens to report the data. A potential concern is that visitors may not report waste within national parks, assuming it is the national park's responsibility, which could lead to data gaps. This may contribute to why only 1.61% of reported dumpsites were in protected areas.

FUTURE DEVELOPMENTS

Ongoing promotion of the Hulladékradar app within the protected areas is recommended to increase reporting coverage.